US008755619B2

(12) **United States Patent**
Choi et al.

(10) **Patent No.: US 8,755,619 B2**
(45) **Date of Patent: Jun. 17, 2014**

(54) **METHOD AND APPARATUS FOR ENCODING AND DECODING IMAGE DATA USING RUN OF THE IMAGE DATA**

(75) Inventors: **Dai-Woong Choi**, Seoul (KR); **Jung-Woo Kim**, Seoul (KR); **Sung-Bum Park**, Seongnam-si (KR); **Jae-Won Yoon**, Seoul (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-Si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 673 days.

(21) Appl. No.: **12/950,163**

(22) Filed: **Nov. 19, 2010**

(65) **Prior Publication Data**

US 2011/0116721 A1 May 19, 2011

(30) **Foreign Application Priority Data**

Nov. 19, 2009 (KR) 10-2009-0112272
Jun. 21, 2010 (KR) 10-2010-0058673

(51) **Int. Cl.**
G06K 9/46 (2006.01)

(52) **U.S. Cl.**
USPC **382/245**

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,308,150 B2 * 12/2007 Yokose 382/245
7,454,073 B2 * 11/2008 Chen et al. 382/239
7,751,633 B1 * 7/2010 Mukherjee 382/239
8,121,427 B2 * 2/2012 Tian et al. 382/245
8,175,401 B2 * 5/2012 Taniguchi et al. 382/245
8,254,700 B1 * 8/2012 Rastogi 382/232
2002/0034331 A1 * 3/2002 Miura 382/239
2002/0061141 A1 * 5/2002 Kobayashi 382/233
2004/0071356 A1 * 4/2004 Sudharsanan et al. 382/244
2005/0068551 A1 * 3/2005 Eldridge et al. 358/1.9
2005/0169364 A1 * 8/2005 Singh 375/240
2005/0232501 A1 * 10/2005 Mukerjee 382/239
2007/0116267 A1 * 5/2007 Speirs et al. 380/28
2008/0107174 A1 * 5/2008 Roman 375/240.02
2009/0022413 A1 * 1/2009 Singh 382/244
2009/0060026 A1 * 3/2009 Park et al. 375/240.01
2009/0067733 A1 * 3/2009 Ballerini 382/237
2010/0027625 A1 * 2/2010 Wik et al. 375/240.12

OTHER PUBLICATIONS

Brahimi, Z.; Saadi, K.A.; Baraka, N., "A lossless image compression algorithm using variable block size segmentation," Industrial Electronics Society, 1998. IECON '98. Proceedings of the 24th Annual Conference of the IEEE, vol. 3, no., pp. 1471,1476 vol. 3, Aug. 31-Sep. 4, 1998.*

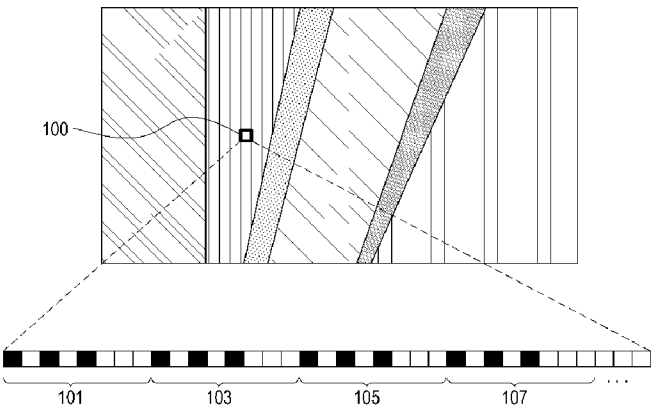
* cited by examiner

Primary Examiner — Atiba O Fitzpatrick
Assistant Examiner — Thomas A James
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

An encoding method includes selecting a run detection method in accordance with characteristics of image data, generating a run value by detecting a run that is repeated in the image data in accordance with the selected run detection method, generating run count bits by counting the number of repetitions of the detected run, and performing a run-length encoding using the detected run values and the run count bits. The run detection method includes a coefficient run detection method that detects a run based on pixel values, a pattern run detection method that detects the run based on whether the pixel blocks have a specified pattern, a difference run detection method that detects the run based on a difference value between two successive pixel values, and a residual run detection method that detects the run based on an error value that is a difference value between an actual pixel value and a predicted value.

24 Claims, 8 Drawing Sheets



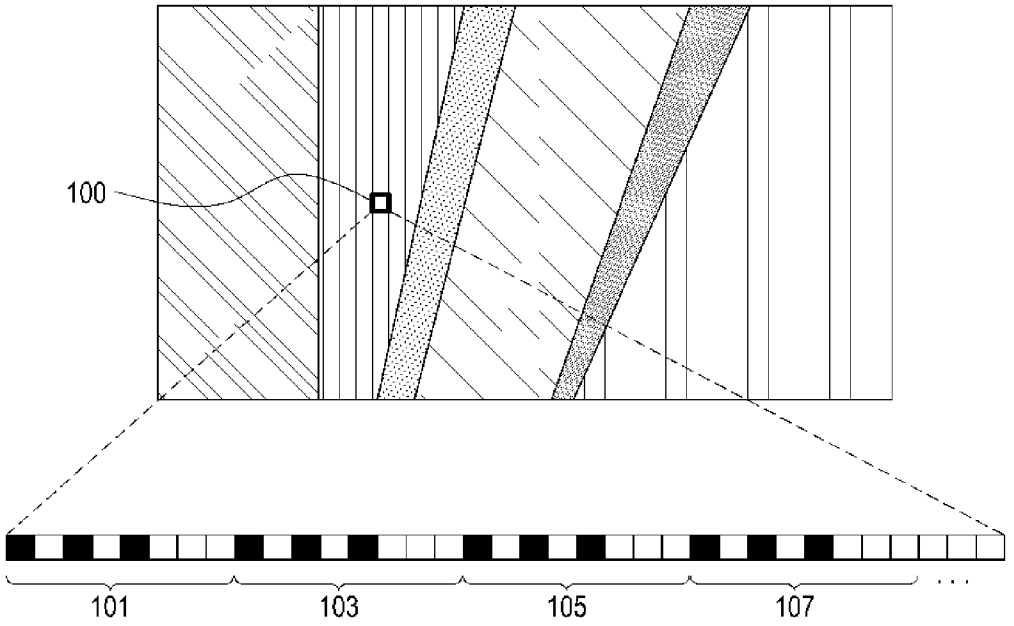

100
101
103
105
107

FIG.1

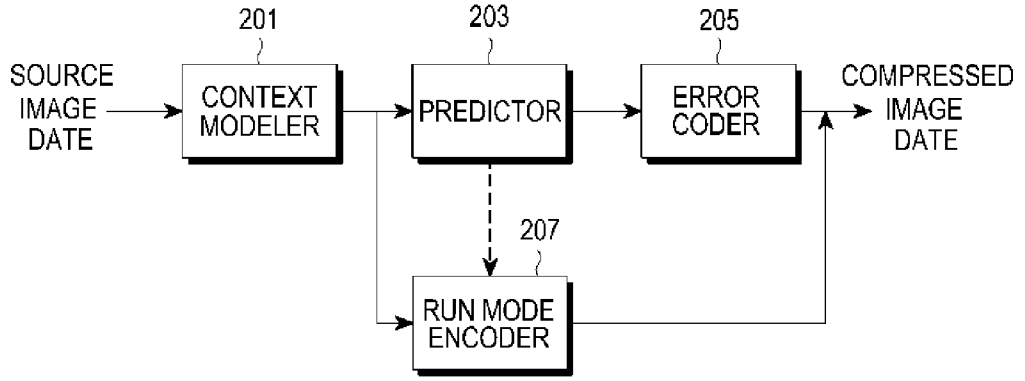

201
203
205
SOURCE IMAGE DATE
CONTEXT MODELER
PREDICTOR
ERROR CODER
COMPRESSED IMAGE DATE
207
RUN MODE ENCODER

FIG.2

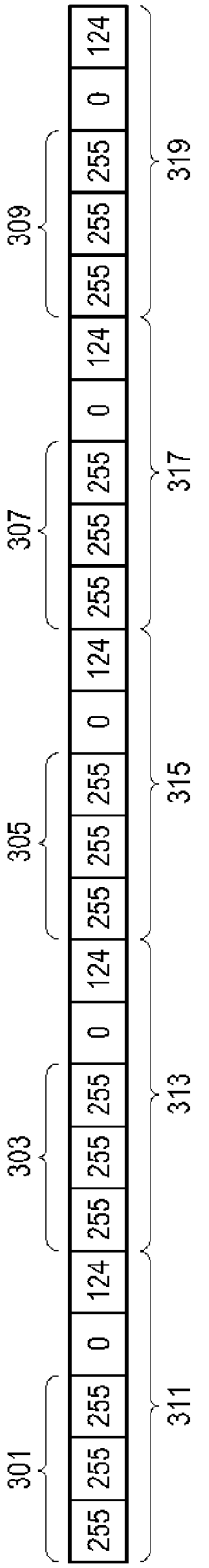

301
303
305
307
309
311
313
315
317
319
255 255 255 0 124 255 255 255 0 124 255 255 255 0 124 255 255 255 0 124

FIG.3A

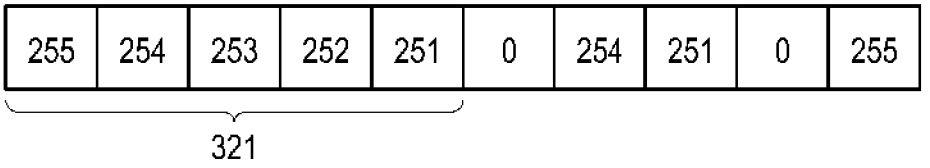

255
254
253
252
251
0
254
251
0
255
321

FIG.3B

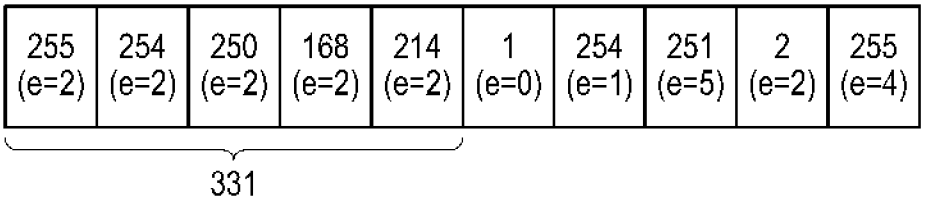

255 (e=2)
254 (e=2)
250 (e=2)
168 (e=2)
214 (e=2)
1 (e=0)
254 (e=1)
251 (e=5)
2 (e=2)
255 (e=4)
331

FIG.3C

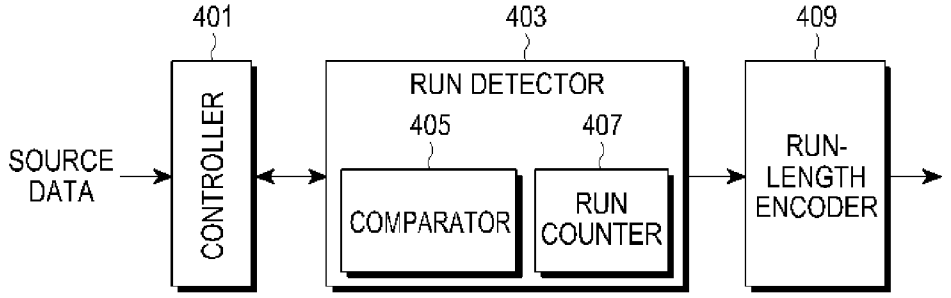

401
403
409
SOURCE DATA
CONTROLLER
RUN DETECTOR
405
407
COMPARATOR
RUN COUNTER
RUN-LENGTH ENCODER

FIG.4

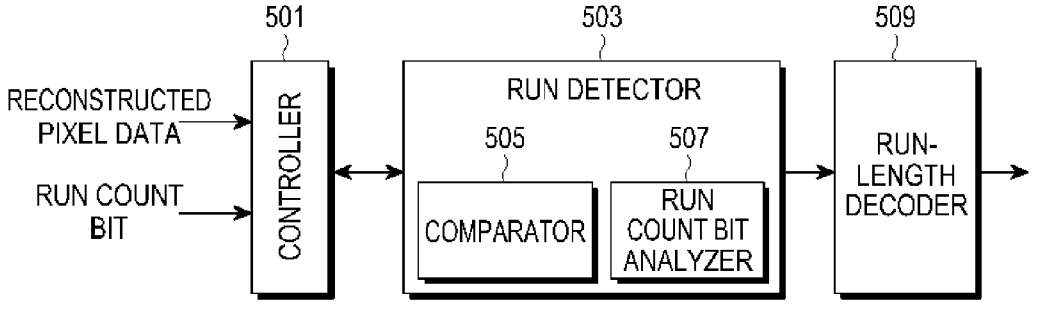

501
503
509
RECONSTRUCTED PIXEL DATA
RUN COUNT BIT
CONTROLLER
RUN DETECTOR
505
507
COMPARATOR
RUN COUNT BIT ANALYZER
RUN-LENGTH DECODER

FIG.5

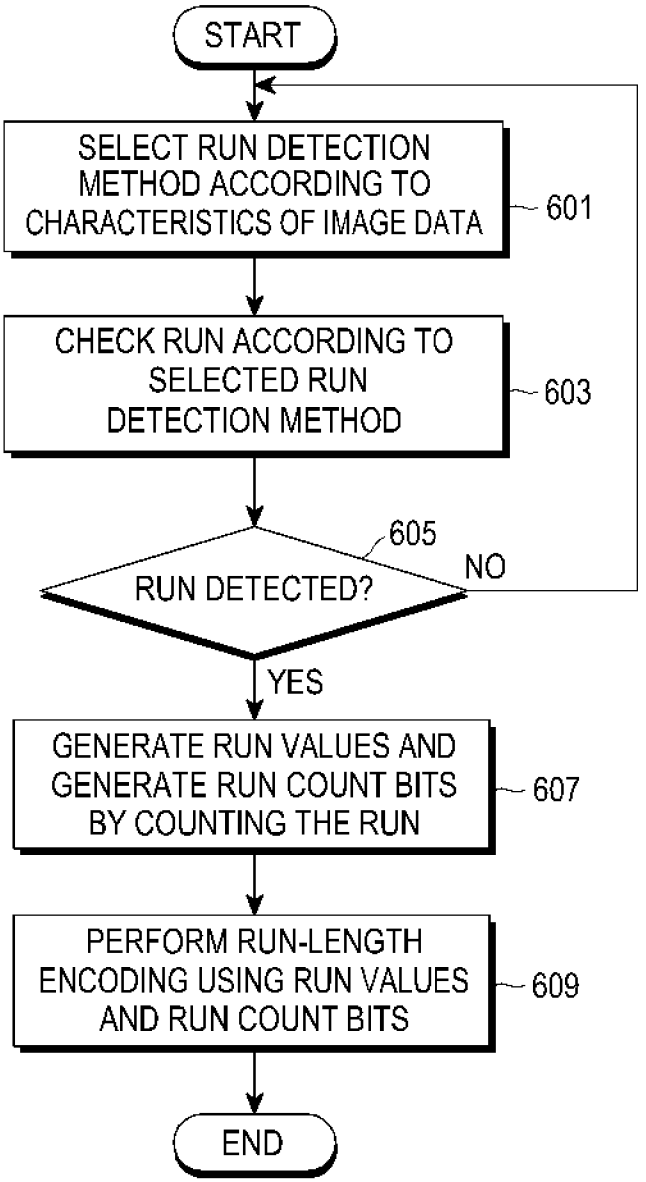

START
SELECT RUN DETECTION METHOD ACCORDING TO CHARACTERISTICS OF IMAGE DATA
601
CHECK RUN ACCORDING TO SELECTED RUN DETECTION METHOD
603
605
RUN DETECTED?
NO
YES
GENERATE RUN VALUES AND GENERATE RUN COUNT BITS BY COUNTING THE RUN
607
PERFORM RUN-LENGTH ENCODING USING RUN VALUES AND RUN COUNT BITS
609
END

FIG.6

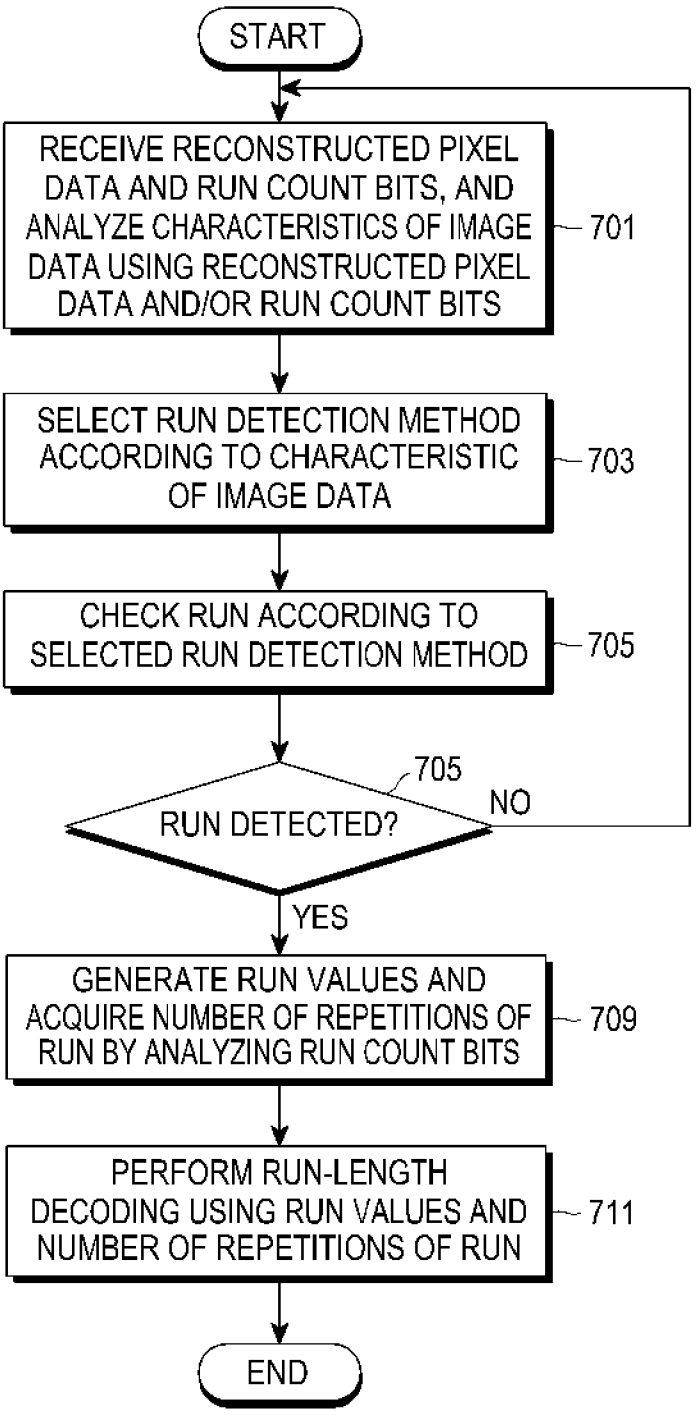

START
RECEIVE RECONSTRUCTED PIXEL DATA AND RUN COUNT BITS, AND ANALYZE CHARACTERISTICS OF IMAGE DATA USING RECONSTRUCTED PIXEL DATA AND/OR RUN COUNT BITS
701
SELECT RUN DETECTION METHOD ACCORDING TO CHARACTERISTIC OF IMAGE DATA
703
CHECK RUN ACCORDING TO SELECTED RUN DETECTION METHOD
705
705
RUN DETECTED?
NO
YES
GENERATE RUN VALUES AND ACQUIRE NUMBER OF REPETITIONS OF RUN BY ANALYZING RUN COUNT BITS
709
PERFORM RUN-LENGTH DECODING USING RUN VALUES AND NUMBER OF REPETITIONS OF RUN
711
END

FIG.7

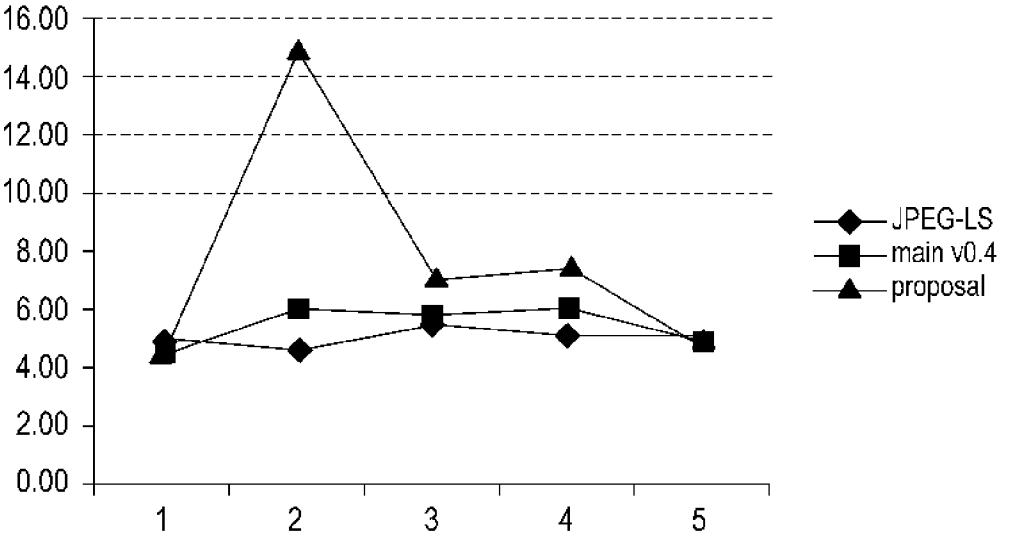

16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1
2
3
4
5
JPEG-LS
main v0.4
proposal

FIG.8

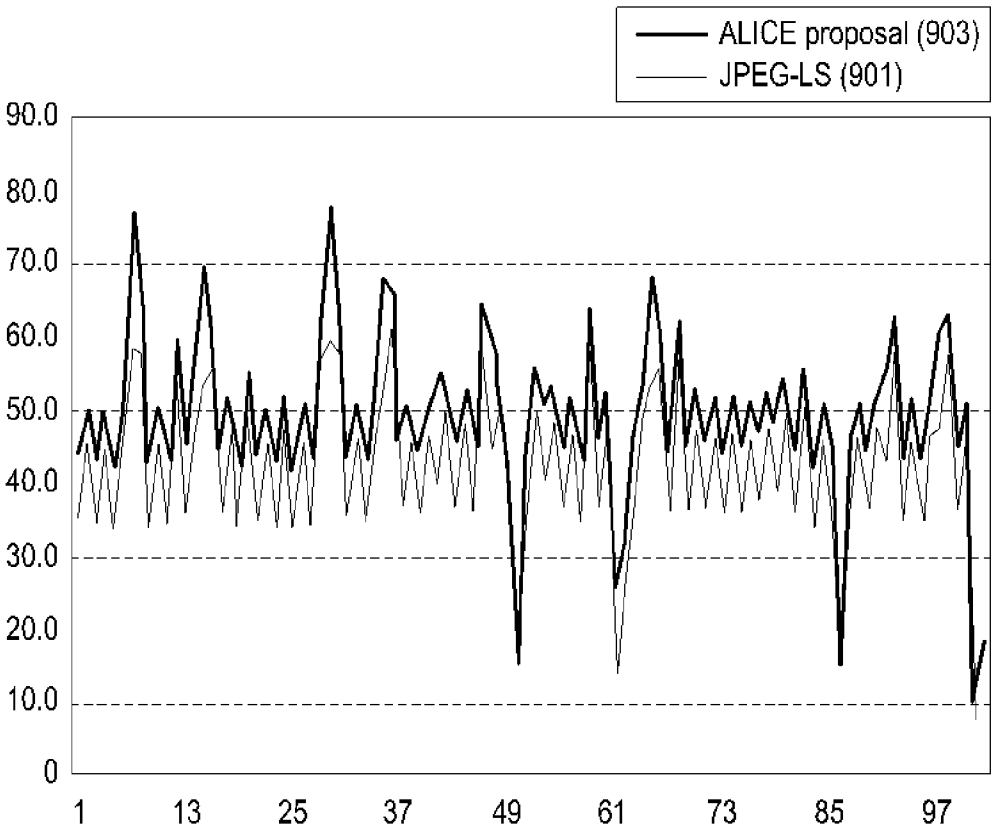

ALICE proposal (903)
JPEG-LS (901)
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
1
13
25
37
49
61
73
85
97

FIG.9

METHOD AND APPARATUS FOR ENCODING AND DECODING IMAGE DATA USING RUN OF THE IMAGE DATA

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the priority under 35 U.S.C. §119 (a) of Korean Patent Application Nos. 10-2009-0112272 and 10-2010-0058673, filed in the Korean Intellectual Property Office on Nov. 19, 2009, and Jun. 21, 2010, respectively, the disclosures of which are hereby incorporated herein in their entireties by reference.

BACKGROUND

1. Field

The exemplary embodiments relate to a method and apparatus for encoding and decoding image data, and more particularly to a method and apparatus for encoding and decoding image data using a run of the image data.

2. Description of the Related Art

In general, in order to perform a lossless compression of image data, an entropy method is used. A representative example of the entropy method is a run-length coding method.

The run-length coding method is a coding method that compresses image data by processing the same pixel values as a run if the same pixel values are successively generated. In the case of using such a run-length coding in an image having a high resolution, more efficient compression of image data can be performed if the run is generated.

On the other hand, pixels that constitute image data may be repeated with a predetermined pattern. Particularly, in the case of image data for a printer, a facsimile, and the like, such a predetermined pattern is frequently formed. FIG. **1** is a diagram illustrating an example of image data composed of patterns. Referring to FIG. **1**, the reference numeral "100" is composed of reference numerals "101" to "107". It can be seen that pixels constituting the reference numerals "101" to "107" have the same pixel structure.

Also, image data may have different patterns or run types in accordance with its characteristics. For example, in a background image in which pixel values are scarcely changed or a gradation image in which pixel values are successively and constantly changed, different types of patterns or runs may be generated. The run-length coding method in the related art performs the run-length coding without considering diverse characteristics of the image data.

SUMMARY

Accordingly, exemplary embodiments have been made to solve the above-mentioned aspects occurring in the related art, and the exemplary embodiment provides a method and apparatus for efficiently encoding and decoding image data.

Also, the exemplary embodiment provides a method and apparatus for encoding and decoding image data, which can recognize patterns of the image data and process pixels having duplicate patterns using a run.

Also, the exemplary embodiment provides a method and apparatus for encoding and decoding image data, which can select diverse run detection methods in accordance with the characteristics of the image data.

In accordance with an aspect of the exemplary embodiment, there is provided a method of encoding image data, which includes the steps of analyzing the characteristics of image data and selecting a run detection method in accordance with the analyzed characteristics of the image data; detecting a run using data to be used for run detection in accordance with the selected run detection method; and performing a run-length coding in accordance with the detected run.

In accordance with another aspect of the exemplary embodiment, there is provided an apparatus for encoding image data, which includes a controller analyzing the characteristics of image data, selecting a run detection method in accordance with the analyzed characteristics of the image data, and outputting data to be used for run detection in accordance with the selected run detection method; a run detector detecting a run from the data to be used for the run detection in accordance with the selected run detection method; and a run-length encoder performing a run-length coding in accordance with the detected run.

In accordance with still another aspect of the exemplary embodiment, there is provided a method of decoding image data, which includes the steps of receiving reconstructed pixel data and run count bits; selecting a run detection method in accordance with the characteristics of the image data by analyzing at least one of the received reconstructed pixel data and the run count bits; detecting a run using data to be used for run detection in accordance with the selected run detection method; and performing a run-length decoding in accordance with the detected run.

In accordance with still another aspect of the exemplary embodiment, there is provided an apparatus for decoding image data, which includes a controller receiving reconstructed pixel data and run count bits, selecting a run detection method in accordance with the characteristics of the image data by analyzing at least one of the received reconstructed pixel data and the run count bits, and outputting data to be used for run detection in accordance with the selected run detection method; a run detector detecting a run using the data to be used for the run detection in accordance with the selected run detection method; and a run-length decoder performing a run-length decoding in accordance with the detected run.

Effects according to the configuration of the exemplary embodiment is as follows.

The encoding and decoding are performed by detecting patterns included in image data in the unit of a block and performing a run processing of the pixel patterns detected in the unit of a block, and thus the encoding efficiency is increased by 65% at maximum in comparison to the method in the related art. Accordingly, the image data processing speed can be increased. Also, the run encoding and decoding can be performed by selecting a run processing method that suits the characteristics of the corresponding image data among diverse processing methods, and thus the encoding and decoding efficiency can be heightened.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects and features of the exemplary embodiment will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a diagram explaining an example of image data composed of a pattern;

FIG. **2** is a diagram illustrating the configuration of an image encoding apparatus using a run-length coding method according to an exemplary embodiment;

FIG. **3**A is a diagram explaining a coefficient run detection method and a pattern run detection method according to an exemplary embodiment;

FIG. **3**B is a diagram explaining a difference run detection method according to an exemplary embodiment;

FIG. **3**C is a diagram explaining a residual run detection method according to an exemplary embodiment;

FIG. **4** is a diagram explaining an operation of a run mode encoder **207** of FIG. **2** according to an exemplary embodiment;

FIG. **5** is a diagram explaining a run mode decoding apparatus according to an exemplary embodiment;

FIG. **6** is a diagram explaining a run-length encoding method according to an exemplary embodiment;

FIG. **7** is a diagram explaining a run-length decoding method according to an exemplary embodiment;

FIG. **8** is a diagram explaining the encoding efficiency of a pattern run-length encoding method according to an exemplary embodiment; and

FIG. **9** is a diagram explaining the encoding efficiency of a pattern run-length encoding method according to an exemplary embodiment.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Hereinafter, exemplary embodiments will be described with reference to the accompanying drawings. In the following description, the same elements will be designated by the same reference numerals although they are shown in different drawings. Further, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the exemplary embodiment rather unclear.

According to the basic concept of the exemplary embodiment, an appropriate run-length method is selected in accordance with the characteristics of image data, a run value is generated by detecting a repeating run in the image data in accordance with the selected run detection method, run-length bits are generated by counting the number of repetitions of the detected run, and a run-length coding is performed using the detected run value and the run count bits. Also, the run detection method applied to the exemplary embodiment may be a coefficient run detection method that detects a run based on pixel values, a pattern run detection method that detects a run based on whether the pixel values of a pixel block form a specified pattern, a difference run detection method that detects a run based on a difference value between two successive pixel values, and a residual run detection method that detects a run based on an error value that is a difference value between an actual pixel value and a predicted value. Hereinafter, an exemplary embodiment will be described in detail.

FIG. **2** is a diagram illustrating the configuration of an image encoding apparatus using a run-length coding method according to an exemplary embodiment.

An encoder **200** includes a context modeler **201**, a predictor **203**, a run mode encoder **207**, and an error encoder **205**. The context modeler **201** performs a context modeling with respect to input source image data, and transfers the result of context modeling to the predictor **203** and/or run-mode encoder **207**.

Generally, encoding of the image data is performed using a prediction encoding method. However, according to an exemplary embodiment, a run mode encoding method is used to efficiently encode the image data, and the prediction encoding method and the run-mode encoding method can be selectively used. That is, it is determined whether the run-mode encoding method or the prediction encoding method is appropriate in accordance with the characteristics of the image data, and one of the two methods can be selected accordingly. For example, if the image data has a lot of margin, it is frequent that the same pixels successively appear, and the run-mode encoding method is used with respect to the image data.

The predictor **203** performs encoding of the image data in accordance with the prediction encoding method. That is, the pixel value of the current pixel is predicted using neighboring pixels of the current pixel, a predicted value is determined, and the determined predicted value is encoded to output the encoded value to the error encoder **205**. Also, the error value that is a difference value between the actual pixel value of the current pixel and the predicted value is output to the error encoder **205**. The error encoder **205** encodes the error value, and outputs the encoded predicted value together.

The run mode encoder **207** performs a run-mode encoding in accordance with the run detection method according to an exemplary embodiment. The run detection methods provided according to an exemplary embodiment may be the coefficient run detection method that detects a run by comparing pixel values, the difference run detection method that detects the run using a difference value between the pixels, the residual run detection method that detects the run from error values between the actual pixel values and the predicted values, which are outputs of the predictor **203**, and the pattern run detection method detects the same patterns among a plurality of pixel blocks. These methods will be described in detail later.

The run-mode encoder **207** analyzes the characteristics of the image data using data input to the run-mode encoder, selects the run detection method according to the analyzed characteristics, and detects a run according to the selected run detection method to generate a run value. Thereafter, the run-mode encoder **207** generates run count bits by counting the number of repetitions of the detected run, and performs the run-length encoding using the generated run value and the run count bits.

The number of run count bits may be predetermined. For example, it is assumed that the number of run count bits is 3. If the number of repeated runs is "3", the corresponding run count bits become "010". This is under the assumption that the run count of "1" corresponds to the run count bits of "000". The fact that the run count bits are set to 3 bits means that the pattern run can be processed 8 ($=2^3$) times at maximum. On the other hand, the number of run count bits may be changed in accordance with the characteristics of the image data and so on. However, in the following description, it is assumed that the number of run count bits is 3 for convenience in explanation.

The data input to the run mode encoder **207** is typically source image data that is an output of the context modeler **201**. However, in the case where the run-mode encoder **207** selects the residual run detection method as the run detection method, it receives the error values transferred from the predictor **203**, and detects the run using the transferred error value.

The configuration of the run mode encoder **207** will be described with reference to FIG. **4**.

Hereinafter, the respective run detection methods according to exemplary embodiments will be described.

FIG. **3**A is a diagram explaining a coefficient run detection method and a pattern run detection method according to an exemplary embodiment.

The coefficient run detection method will be explained with reference to reference numerals **301**, **303**, **305**, **307**, and **309**.

It can be seen that the pixel value 255 is repeated three times in the reference numerals **301**, **303**, **305**, **307**, and **309**. The coefficient run means that the successive pixels have the same pixel values.

The method of detecting the coefficient run and encoding the image data is as follows.

First, pixel values of the pixels of the reference numerals **301** and **302** are compared. If both have the same value, the coefficient run is detected. If the coefficient run is detected, the run count bits are generated by counting the number of repetitions of the run. In an example of FIG. **3**A, the run value becomes 255, and the run count bit value becomes 1. During the run-length encoding using the run value and the run count bit, the pixel value "255" is encoded twice, and the count bit value "1" is encoded. The reason why the pixel value "255" is encoded twice is that the successive same pixel values should be encoded in all in order for the decoder to detect the run in the same method as the encoder.

On the other hand, the pattern run detection method will be described with reference to reference numerals **311**, **313**, **315**, **317**, and **319**.

Referring to FIG. **3**A, by making 5 pixel blocks in one unit, it can be seen that the pixel value patterns of the respective pixel blocks are the same. That is, the reference numerals **311**, **313**, **315**, **317**, and **319** have the same pixel patterns (255, 255, 250, 0, 124). The pattern run according to an exemplary embodiment means that the pixel blocks having a fixed size have the same pixel patterns in all.

Specifically, an example of the pattern run detection method is as follows.

First, the size of a pixel block for detecting the pattern, that is, the window size, is determined. Then, the two pixel blocks having the size corresponding to the window size are compared with each other. If the pixel values of the pixel blocks are not the same as a result of comparison, it means that the pattern is not detected, and the pattern detection is repeated with the window size re-determined. It is assumed that the window size is initially determined as "5" in an example of FIG. **3**A. If the first pixel block **311** and the second pixel block **313** are compared, their pixel values are the same, and thus the pattern has been detected. Accordingly, run count bits are generated by counting the number of repetitions of the pattern in the following pixel blocks. In the case of performing the run-length coding in the above-described example, the run value is repeated twice and encoded, and the run count bits are encoded.

On the other hand, the repetition of the pattern detection may be repeated until the typical window size becomes "1". For example, the pixel pattern can be searched for by reducing the window size one by one, starting from "N" to "1". Here, in the case where the window size is "1", the same effect as that in the coefficient run detection method is obtained. However, the repetition of the pattern text until the current window size becomes "1" is merely exemplary, and the threshold value of the window size may be changed according to its design. For example, in the case of increasing the window size in an ascending order, the threshold value of the window size would be a value that is not "1".

The encoding efficiency according to the pattern run detection method is calculated as follows. It is assumed that 8 bits are necessary to encode one pixel and the run count bits are 3 bits. In this case, the size of the image data before the initial encoding operation becomes 200 bits (=25 pixels×8 bits). When the number of bits that are encoded according to the assumption is calculated, the size of the image data after the encoding is as follows. That is, the size of the image data becomes 83 bits (=the encoding of pixels of reference numerals **311** (8 bits×5=40 bits)+the encoding of pixels of reference numerals **313** (8 bits×5=40 bits)+the encoding of run count bits (3 bits)). The result of encoding efficiency according to the pattern run detection method will be additionally described with reference to FIG. **8** below.

On the other hand, in explaining the above-described pattern run detection method, it is exemplified that the pattern is detected by comparing two pixel blocks. However, according to circumstances, the pattern may be detected by comparing three or more pixel blocks. In this case, a prediction encoding method that performs prediction encoding among pixels constituting the respective pixel blocks may be used in combination.

FIG. **3**B is a diagram explaining a difference run detection method according to an exemplary embodiment.

In FIG. **3**B, it can be seen that differences between pixel values of the pixels in the reference numeral **321** are all "1". The difference run detection method detects a run if the differences between the pixel values of the pixels in the reference numeral **321** are the same in all. The difference run detection method is different from the coefficient run method on the points that the subject of comparison for the run detection is a difference value between two pixels.

FIG. **3**C is a diagram explaining a residual run detection method according to an exemplary embodiment.

In FIG. **3**C, for each pixel, an actual pixel value and an error value are indicated in parentheses. For example, in the first pixel, the pixel value is indicated as "255" and its error value is "2". Here, no special rule can be found between the actual pixel values of the pixels in the reference numeral **331**. However, it can be seen that error values of the pixels in the reference numeral **331** are all "2". The residual run indicates such a case where the same error values are successively generated. The residual run detection method is different from the coefficient run method on the points that the subject of comparison for the run detection is an error value between the pixels.

As described above, the coefficient run, the pattern run, the difference run, and the residual run have been described. However, in relation to the pattern run, the modified method detects the pattern based on whether the pixel values have a predetermined pattern as shown in FIG. **3**B. However, the pattern may be detected based on whether the difference values have a specified pattern as used in the difference run or whether error values used in the residual run form a predetermined pattern. As described above, the pattern run detection method can encode the image data using the pattern that is found in the image data on any basis.

Hereinafter, the operation of the run mode encoder **207** as described above with reference to FIG. **2** will be described in detail.

FIG. **4** is a diagram explaining the operation of the run mode encoder **207** of FIG. **2** according to an exemplary embodiment.

The run mode encoder **207** includes a controller **401**, a run detector **403**, and a run-length encoder **409**.

The controller **401** receives source data, analyzes the characteristics of the image data, and selects a run detection method for the run detection according to the characteristics of the source data. That is, in accordance with the characteristics of the source data, at least one of the coefficient run detection method, the difference run detection method, the residual run detection method, and the pattern run detection method may be selected. As an example, if the image data

corresponds to a smooth image as a result of analyzing the characteristics of the image data, the controller **401** selects the pattern run detection method. On the other hand, if the image data corresponds to a gradation image, the controller **401** selects the difference run detection method. If the image data corresponds to an angle image, the controller **401** selects the residual run detection method.

On the other hand, the controller **401** may select a plurality of run detection methods and determine the order in which they are performed. For example, the controller **401** may perform the run detection according to the coefficient run method and then perform the run detection according to the difference run method. Also, the controller **401** outputs data to be used for the run detection to the run detector **403** according to the selected run detection method.

If the coefficient run is selected, the controller **401** would directly output the pixel values to the run detector **403**. Also, if the pattern run is selected, the controller **401** determines the window size for pixel blocks, and outputs the image data to the run detector **403** in the unit of a pixel block according to the determined window size. On the other hand, if the difference run is selected, the controller **401** calculates difference values between pixels, and outputs the calculated difference values to the run detector **403**. If the residual run is selected, the controller **401** receives the error values by controlling the predictor **203** of FIG. **2** and outputs the error values to the run detector **403**.

The run detector **403** includes a comparator **405** and a run counter **407**. The comparator **405** detects the run by comparing input data from the controller **401** according to the selected detection method. That is, in the coefficient run method, the comparator **405** checks whether two successive pixel values coincide with each other, and in the pattern run method, the comparator **405** checks whether all pixel values of the two pixel blocks coincide with each other. Also, in the difference run method, the comparator **405** checks whether two successive difference values coincide with each other, and in the residual run method, the comparator **405** checks whether two successive error values coincide with each other. If they coincide with each other as a result of the comparison, the comparator **405** generates a run value and outputs the run value to the run-length encoder **409**. If they do not coincide with each other, it means that no run is detected, and thus the comparator **405** informs the controller **401** that no run is detected. The controller **401**, which has received information regarding the non-detection of the run, selects another run detection method, or interrupts the run mode encoding and performs a prediction encoding method.

On the other hand, the run counter **407** counts the run, generates and outputs run count bits to the run-length encoder **409**. The run-length encoder **409** encodes the image data using the run values and the run count bits.

FIG. **5** is a diagram explaining a run mode decoding apparatus according to an exemplary embodiment.

The run mode decoding apparatus according to an exemplary embodiment has a configuration corresponding to the run mode encoder **207**. The detailed operation of the run mode decoding apparatus is as follows.

A controller **501** receives reconstructed pixel data and run count bits. The run count bits are transferred to a run detector **503**. For reference, the reconstruction pixel data is pixel data that is received in correspondence to the pixel data encoded by the encoder. The controller **501** analyzes the characteristics of the image data using the reconstructed pixel data and/or the run count bits, and selects the run detection method for the run detection according to the characteristics of the image data. That is, the controller **501** selects at least one of the coefficient run detection method, the difference run detection method, the residual run detection method, and the pattern run detection method. The controller **501** may use another method except for the four run detection methods as described above. Also, in the case where a plurality of run detection methods is selected, the controller **501** may determine the order in which they are performed. For example, the controller **501** may perform the run detection according to the coefficient run method and then perform the run detection according to the difference run method. Also, the controller **501** outputs data to be used for the run detection to the run detector **503** according to the selected run detection method.

If the coefficient run is selected, the controller **501** would directly output the pixel values to the run detector **503**. Also, if the pattern run is selected, the controller **501** determines the window size for pixel blocks, and outputs the image data to the run detector **503** in the unit of a pixel block according to the determined window size. On the other hand, if the difference run is selected, the controller **501** calculates difference values between pixels, and outputs the calculated difference values to the run detector **503**. If the residual run is selected, the controller **501** receives the error values by controlling a predictor (not illustrated) and outputs the error values to the run detector **503**. For reference, the predictor for the prediction decoding may be a configuration of a decoder that corresponds to the predictor **203** of FIG. **2**.

The run detector **503** includes a comparator **505** and a run count bit analyzer **507**. The comparator **505** detects the run by comparing input data from the controller **501** according to the selected detection method. That is, in the coefficient run method, the comparator **505** checks whether two successive pixel values coincide with each other, and in the pattern run method, the comparator **505** checks whether all pixel values of the two pixel blocks coincide with each other. Also, in the difference run method, the comparator **505** checks whether two successive difference values coincide with each other, and in the residual run method, the comparator **505** checks whether two successive error values coincide with each other. If they coincide with each other as a result of comparison, the comparator **505** generates a run value and outputs the run value to a run-length decoder **509**. If they do not coincide with each other, it means that no run is detected, and thus the comparator **505** informs the controller **501** that no run is detected. The controller **501**, which has received information regarding the non-detection of the run, selects another run detection method, or interrupts the run mode decoding and performs a prediction decoding method.

On the other hand, the run count bit analyzer **507** analyzes the run count bits and outputs the result of analysis to the run-length decoder **509**. The run-length decoder **509** decodes the image data using the run values and the run count bits.

FIG. **6** is a diagram explaining a run-length encoding method according to an exemplary embodiment.

In step **601**, the characteristics of the image data are analyzed, and the run detection method is selected according to the characteristics of the image data. In step **603**, the run is checked according to the determined run detection method. Since the run detection methods proposed according to the exemplary embodiment have been described in detail with reference to FIG. **3**, the detailed description thereof will be omitted. In step **605**, if the run is detected, the run value is generated, and the run count bits are generated by counting the run. If the run is not detected, the processing returns to step **601**, and another run detection method can be selected. Also, although not illustrated, the run mode encoding may be interrupted. In step **607**, the run-length encoding is performed using the generated run values and run count bits.

FIG. **7** is a diagram explaining a run-length decoding method according to an exemplary embodiment.

In step **701**, the reconstructed pixel data and the run count bits are received. In step **703**, the characteristics of the image data are analyzed using the reconstructed pixel data and/or the run count bits, and the run detection method is selected according to the characteristics of the image data. In step **705**, the run is checked according to the determined run detection method. Since the run detection methods proposed according to the exemplary embodiment have been described in detail with reference to FIG. **3**, the detailed description thereof will be omitted. If the run is detected in step **707**, the run value of the detected run is generated, and the run count bits are generated by counting the run. If the run is not detected, the processing returns to step **701**, and another run detection method can be selected. Also, although not illustrated, the run mode decoding may be interrupted. In step **709**, the run-length decoding is performed using the generated run values and run count bits.

FIG. **8** is a diagram explaining the encoding efficiency of a pattern run-length encoding method according to an exemplary embodiment.

The reference numeral "801" denotes the encoding efficiency of a main v 0.4 encoding method, "803" denotes the encoding efficiency of a JPEG LS encoding method, and "805" denotes the encoding efficiency of the pattern run length encoding method according to the exemplary embodiment. As illustrated, it can be seen that the encoding efficiency of the pattern run length according to the exemplary embodiment is considerably high in comparison to the existing encoding method. As an example, the encoding method according to the exemplary embodiment has an improved gain by about 65% in comparison to the main v 0.4 encoding method.

FIG. **9** is a diagram explaining the encoding efficiency of a run mode encoding apparatus of FIG. **4** according to an exemplary embodiment.

The reference numeral "901" denotes the encoding efficiency of a JPEG LS encoding method, and "903" denotes the encoding efficiency of the encoding method according to the exemplary embodiment. The JPEG LS encoding method shows the encoding efficiency of 31.26%, and the encoding method according to the exemplary embodiment shows the encoding efficiency of 44.62%. Accordingly, the encoding method according to the exemplary embodiment has an improved gain by about 43% in comparison to the JPEG LS encoding method.

Since a specified run is frequently generated in an image that is displayed on a monitor for a printer output, the exemplary embodiments can be efficiently applied to the decoding of the image data for the printer output. However, the exemplary embodiments are not limited thereto, and the exemplary embodiments can be applied to the encoding and decoding of all image data in which a specified run is generated. Also, in further extension, so far as a run is found in the field where the run-length encoding and decoding are used, the run-length encoding and decoding concept according to the exemplary embodiments could be applied thereto.

While the various aspects have been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the exemplary embodiments as defined by the appended claims.

What is claimed is:

1. A method of encoding image data, the method comprising:

analyzing characteristics of image data;

selecting a run detection method based on the analyzed characteristics of the image data;

detecting a run using data to be used for run detection based on the selected run detection method; and

performing a run-length coding based on the detected run,

wherein in response to the selected run detection method being a pattern run detection method, the detecting the run comprises detecting a pattern run from a plurality of pixel blocks, each of the pixel blocks having a same size, the pattern run indicating the plurality of pixel blocks all have the same pixel pattern.

2. The method as claimed in claim **1**, wherein the selecting the run detection method selects at least one of a coefficient run detection method that detects the run based on pixel values, a difference run detection method that detects the run based on a difference value between two successive pixel values, and a residual run detection method that detects the run based on an error value that is a difference value between an actual pixel value and a predicted value.

3. The method as claimed in claim **1**, wherein when the pattern run detection method is selected, the detecting determines the size of the pixel block to detect the pattern run based on the determined size of the pixel block, and if the pattern run is not detected based on the determined size of the pixel block, re-determine the size of the pixel block to re-detect the pattern run based on the re-determined size of the pixel block.

4. The method as claimed in claim **1**, wherein the detecting the run comprises generating a run value by detecting the run by comparison of two successive data among data required for the selected run detection method, and generating run count bits by counting a number of repetitions of the detected run.

5. The method as claimed in claim **4**, wherein the performing the run-length encoding performs the run-length encoding using the generated run values and the generated run count bits.

6. An apparatus for encoding image data, comprising a processor configured to analyze characteristics of image data, select a run detection method in accordance with the analyzed characteristics of the image data, and output data to be used for run detection based on the selected run detection method, implement a run detector which detects a run from the data to be used for the run detection based on the selected run detection method, and implement a run-length encoder which performs a run-length coding based on the detected run,

wherein in response to the selected run detection method being a pattern run detection method, the run detector detects a pattern run from a plurality of pixel blocks, each of the pixel blocks having a same size, the pattern run indicating the plurality of pixel blocks all have the same pixel pattern.

7. The apparatus as claimed in claim **6**, wherein the processor is configured to select at least one of a coefficient run detection method which detects the run based on pixel values, a difference run detection method which detects the run based on a difference value between two successive pixel values, and a residual run detection method which detects the run based on an error value which is a difference value between an actual pixel value and a predicted value.

8. The apparatus as claimed in claim **6**, wherein the processor is configured to determine the size of the pixel block to detect the pattern run based on the determined size of the pixel block, and if the pattern run is not detected based on the

determined size of the pixel block, re-determines the size of the pixel block to re-detect the pattern run based on the re-determined size of the pixel block.

9. The apparatus as claimed in claim **7**, wherein when the difference run detection method is selected, the processor is configured to calculate the difference value between the two successive pixel values and outputs the calculated difference value to the run detector.

10. The apparatus as claimed in claim **7**, wherein when the residual run detection method is selected, the processor is configured to calculate the error value transferred from a predictor which predicts the actual pixel value of the corresponding pixel, and outputs the error value to the run detector.

11. The apparatus as claimed in claim **6**, wherein the run detector comprises:

a comparator which generates a run value by detecting the run through comparison of two successive data among data required for the selected run detection method; and

a run count generator which generates run count bits by counting a number of repetitions of the detected run.

12. The apparatus as claimed in claim **11**, wherein the run-length encoder performs the run-length encoding using the generated run values and the generated run count bits.

13. A method of decoding image data, the method comprising:

receiving reconstructed pixel data and run count bits;

selecting a run detection method in accordance with characteristics of the image data by analyzing at least one of the received reconstructed pixel data and the run count bits;

detecting a run using data to be used for run detection in accordance with the selected run detection method; and

performing a run-length decoding in accordance with the detected run,

wherein in response to the selected run detection method being a pattern run detection method, the detecting the run comprises detecting a pattern run from a plurality of pixel blocks, each of the pixel blocks having a same size, the pattern run indicating the plurality of pixel blocks all have the same pixel pattern.

14. The method as claimed in claim **13**, wherein the selecting the run detection method selects at least one of a coefficient run detection method that detects the run based on pixel values, a difference run detection method that detects the run based on a difference value between two successive pixel values, and a residual run detection method that detects the run based on an error value that is a difference value between an actual pixel value and a predicted value.

15. The method as claimed in claim **13**, wherein when the pattern run detection method is selected, the detecting the run determines the size of the pixel block to detect the pattern run based on the determined size of the pixel block, and if the pattern run is not detected based on the determined size of the pixel block, re-determines the size of the pixel block to re-detect the pattern run based on the re-determined size of the pixel block.

16. The method as claimed in claim **13**, wherein the step of detecting the run comprises generating a run value by detecting the run through comparison of two successive data among data required for the selected run detection method, and generating run count bits by counting the number of repetitions of the detected run.

17. The method as claimed in claim **16**, wherein performing the run-length decoding performs the decoding using the generated run values and the generated run count bits.

18. An apparatus for decoding image data, the apparatus comprising a processor configured to receive reconstructed pixel data and run count bits, select a run detection method based on the characteristics of the image data by analyzing at least one of the received reconstructed pixel data and the run count bits, and output data to be used for run detection based on the selected run detection method, implement a run detector which detects a run using the data to be used for the run detection based on the selected run detection method, and implement a run-length decoder which performs a run-length decoding based on the detected run,

wherein in response to the selected run detection method being a pattern run detection method, the run detector detects a pattern run from a plurality of pixel blocks, each of the pixel blocks having a same size, the pattern run indicating the plurality of pixel blocks all have the same pixel pattern.

19. The apparatus as claimed in claim **18**, wherein the processor is configured to select at least one of a coefficient run detection method which detects the run based on pixel values, a difference run detection method which detects the run based on a difference value between two successive pixel values, and a residual run detection method which detects the run based on an error value that is a difference value between an actual pixel value and a predicted value.

20. The apparatus as claimed in claim **18**, wherein the processor is configured to determine the size of the pixel block to detect the pattern run based on the determined size of the pixel block, and if the pattern run is not detected based on the determined size of the pixel block, re-determines the size of the pixel block to re-detect the pattern run based on the re-determined size of the pixel block.

21. The apparatus as claimed in claim **19**, wherein when the difference run detection method is selected, the processor is configured to calculate a difference value between the two successive pixel values and outputs the calculated difference value to the run detector.

22. The apparatus as claimed in claim **19**, wherein when the residual run detection method is selected, the processor is configured to receive an error value transferred from a predictor which predicts the pixel value of the corresponding pixel, and outputs the error value to the run detector.

23. The apparatus as claimed in claim **18**, wherein the run detector comprises:

a comparator which generates a run value by detecting the run through comparison of two successive data among data required for the selected run detection method; and

a run count generator which generates run count bits by counting the number of repetitions of the detected run.

24. The apparatus as claimed in claim **23**, wherein the run-length decoder performs the decoding using the generated run values and the generated run count bits.

* * * * *